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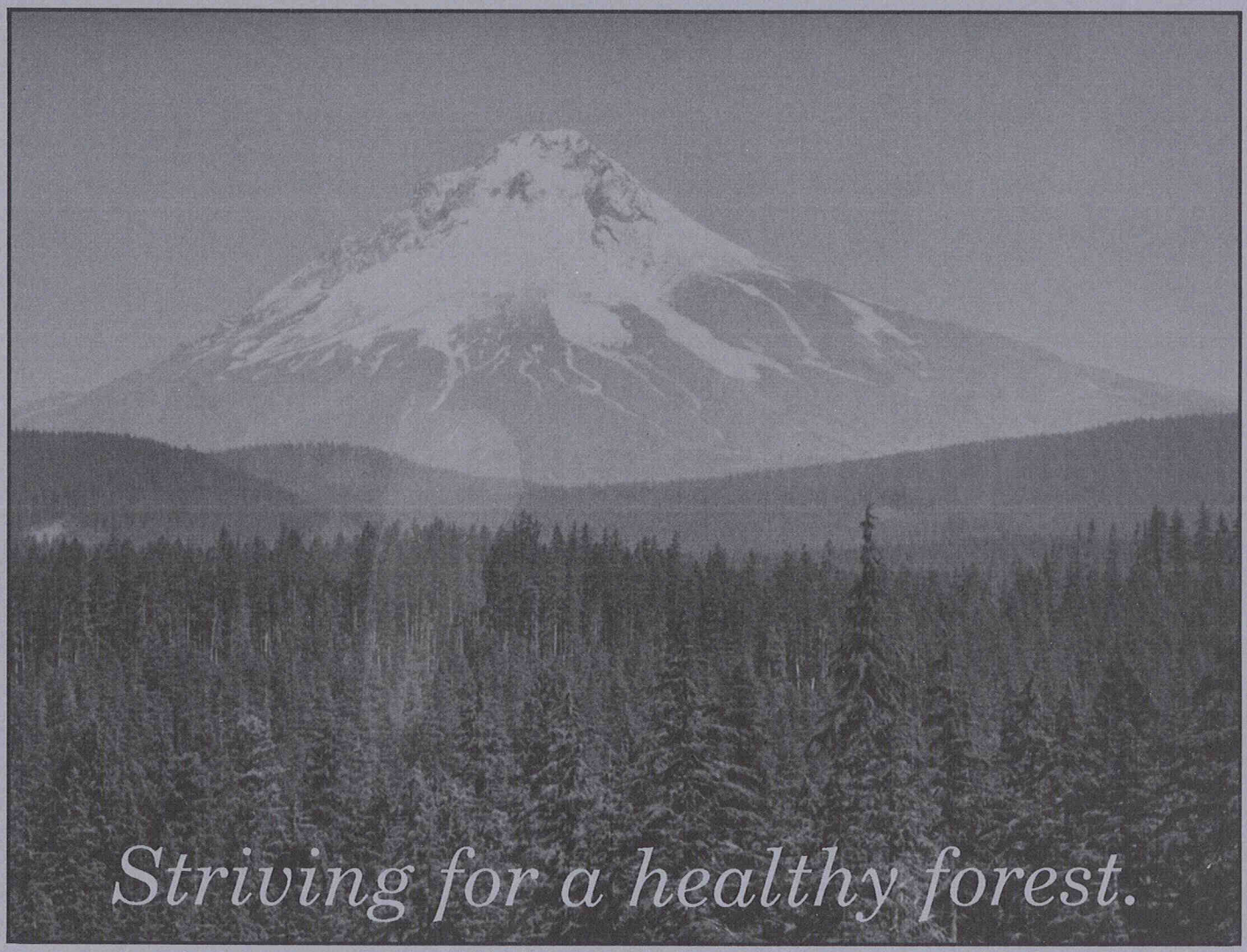
**Pacific
Northwest
Region**

Forest Pest Management

R6-89-03

Biological Evaluation of Western Spruce Budworm on Proposed 1989 Analysis Units



BIOLOGICAL EVALUATION OF WESTERN SPRUCE BUDWORM ON

PROPOSED 1989 ANALYSIS UNITS

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INTRODUCTION

The continuing outbreak of western spruce budworm, Choristoneura occidentalis, has once again prompted forest managers to analyze the situation so they can determine the need for budworm suppression on selected areas of land for which they are responsible. Two questions which surfaced during the analysis process were: (1) what are the predicted insect population levels for 1989 and (2) in what areas are damages predicted to be the most severe.

As a result of Forest requests and discussions between Forest Pest Management personnel and Forest budworm analysis coordinators, geographical areas with resources that had a potential for being adversely affected by western spruce budworm were delineated. These areas are called Analysis Units (AUs), with the initial 17 being delineated by the end of June 1988. Budworm population and tree damage data were gathered from most of these AUs which are located on the Deschutes, Malheur, Mt. Hood, Umatilla, Wallowa-Whitman, and Willamette National Forests, and the Yakima Indian Reservation.

Throughout the summer and into the fall, forest managers made changes by eliminating original AUs from the environmental analysis process, or by dividing or combining original AUs. Of the 21 AUs shown in Table 1, 13 are being formally considered in the analysis and eight have been dropped from further analysis.

This report summarizes the budworm population and tree damage data that were collected from these AUs during Summer and Fall 1988. In addition, this report presents recommendations based on these data combined with aerial survey information and general knowledge of the areas.

METHODS

Pheromone Trapping

Pheromone traps were placed at 10 to 45 sites (one trap per site) within each Analysis Unit (AU) which had been identified and delineated before July 1988 (Table 2, Figures 1-16, 18-19). Traps were hung at eye level on either Douglas-fir or a species of true fir. The approximate location for each trap site was selected without the use of host type or defoliation information and marked as a point on a map. During July, traps were placed on host trees nearest these predetermined locations.

Traps were the milk-carton type which have a tent-like configuration and have the inside covered with a sticky substance. The pheromone used was a 92:8 blend of (E)-11 and (Z)-11 tetradecenal. All baits were 3- by 5-mm polyvinyl chloride pellets impregnated with the pheromone at a strength of 0.0001 percent pheromone by bait weight. One impregnated pellet was placed on a pin and attached to the inside of each trap. Care was used so that pellets did not touch the sticky substance.

Trap retrieval began at the end of moth flight and was completed by mid October. The number of moths in each trap was either counted as the trap was retrieved or counted after the trap had been retrieved and brought into the laboratory.

Tree Data Collection

As the pheromone traps were being retrieved the crews gathered tree data at every third trap site (Figures 1-3, 6-21). Plot center was randomly selected and both variable plot (20 BAF) and fixed plot (1/300 acre) data were gathered using the same plot center.

Following is a list of the data gathered for host trees that fell within the variable radius or fixed radius plots:

Species
Class (live, died during outbreak,
died before outbreak)
DBH
Bare top as a percent of total tree height
Crown ratio
Percent total defoliation (ocular estimate) by crown third
Percent current defoliation (ocular estimate) by crown third
Crown class

Crews also estimated the number of years that western spruce budworm defoliation had been evident on the plot.

The only information recorded for non-host trees was species, DBH, crown ratio, and crown class.

RESULTS

Pheromone Traps

Pheromone trap catches ranged from an average of 1.5 moths/trap on the Clackamas AU to 31.7 on the Sheep Springs AU (Table 2). Moths caught per trap and the predicted defoliation for the subsequent year have been estimated (Charles Sartwell, USDA Forest Service, PNW Experiment Station, personal communication) to be as follows:

0-4 = defoliation undetectable by cursory observation;
5-19 = patchy defoliation within some trees;
20-34 = most trees lightly defoliated;
35-44 = stand moderately defoliated;
45-55 = heavy defoliation of upper crowns;
>55 = heavy defoliation of entire crowns.

There is some uncertainty associated with making predictions of defoliation caused by the larvae of one budworm generation from estimates of male moth populations in the previous generation. However, several data sets have shown a good correlation between these two variables. Based on this prediction scheme, light defoliation is predicted for 11 of 18 AUs sampled, patchy defoliation for 5 of 18, and undetectable defoliation for 1 of 18 (Table 2).

Tree Damage Data

Bare top data collected (Table 3), indicate that none of the AUs is experiencing extensive top-kill or mortality of budworm host trees. The amounts of bare top shown for Reynolds, Halfway, and South NRA are somewhat inflated because these percentages were measured as percent of crown height rather than percent of total tree height.

The percent cumulative defoliation (i.e., percent missing foliage) is a product of severity of defoliation and number of years that defoliation has occurred. The AUs showing the most severe defoliation are Reynolds, Grossman, and South NRA (Table 4). Because of the low number of years that defoliation has been occurring in these AUs, it is doubtful that the cumulative defoliation is as heavy as that recorded. We suspect crew sampling error. Therefore, the actual cumulative defoliation may be somewhat less than that shown in Table 4 for the Grossman, Halfway, South NRA, and Reynolds AUs.

The percent current defoliation (i.e., percent of this year's foliage that is missing) was not extreme in any of the AUs. The highest percentage of trees with heavy defoliation was in the Simcoe AU (Table 5). The percentage of trees with heavy defoliation in the High Rock AU was lower than expected, possibly because none of the plots sampled were located in areas where defoliation appeared to be the most severe.

The percent basal area per acre, trees per acre, and quadratic mean diameters for budworm host trees that were sampled in each AU are shown in Table 6.

A brief discussion of each AU that is being considered formally in the current environmental analysis follows. Refer to Tables 2-6 for specific trap catch, bare top, and defoliation estimates, percent of budworm host tree species, and numbers of plots sampled. Any reference to percent of trees in a category is referring to the percent of trees per acre, as calculated from variable plot data.

DESCHUTES NATIONAL FOREST

Bluegrass

Pheromone trap catches predict light defoliation for 1989. No bare tops were observed and the cumulative defoliation was enough to be recorded on only half of host trees. Current defoliation was detectable on only 76% of host trees. Defoliation has been evident at plot sites for 2 to 3 years.

Recommendations for 1989: No insecticide treatment; pay close attention to 1989 aerial survey; make casual ground observations in June when larvae are feeding; do pheromone trapping.

Sheep Springs

Pheromone trap catches predict light defoliation for 1989, even though this was the highest average catch for any of the AUs sampled. Bare tops were observed on 33% of host trees, with 8% having bare tops greater than 10% of total tree height. Cumulative defoliation was insignificant on 39% of host trees, moderate on 26%, heavy on 18%. Current defoliation was heavy on over half the host trees with most of the rest falling into the "none" or "light" categories. Defoliation has been evident at plot sites for 3 years.

Recommendations for 1989: No insecticide treatment; pay close attention to 1989 aerial survey; gather larval population density information in June using lower crown sampling techniques; do more intensive tree damage data collection and pheromone trapping if warranted by larval data.

Metolius

Pheromone trap catches predict light defoliation for 1989. Bare tops were observed on only 1% of the host trees. Heavy cumulative defoliation was observed on only 1% of host trees with 46% rated as moderate and the remainder in the "none" or light categories. Over half the host trees observed had light current defoliation with 38% being rated as heavy. Defoliation has been evident at plot sites for 2 years.

Recommendations for 1989: No insecticide treatment; pay close attention to 1989 aerial survey; make casual ground observations in June when larvae are feeding; do pheromone trapping.

MT. HOOD NATIONAL FOREST

High Rock

Pheromone trap catches predict patchy defoliation for 1989. Bare tops were observed on only 3% of the host trees within the plots. None of the plots fell within the areas of very heavy defoliation which has been observed from both the air and the ground. Cumulative defoliation was rated as light on 16% of host trees with the remaining 84% being in the "none" category. About one fourth of the host trees had current defoliaton rated as heavy with most of the remaining three fourths in the "none" category. Defoliation has been evident at plot sites for 0 to 3 years.

Recommendations for 1989: Do not treat whole AU with insecticides. However, if resource values are high enough, treatment may be warranted for several areas within the AU which have exhibited heavy defoliation for two or three years. If there is no insecticide treatment, pay close attention to 1989 aerial survey; gather larval population density information in June using lower crown sampling techniques; do more intensive tree damage data collection and pheromone trapping if warranted by larval data; stratify plots by defoliation history.

UMATILLA NATIONAL FOREST

Thimbleberry

Pheromone trap catches predict light defoliation for 1989. No bare tops were observed on 87% of trees with 8% exhibiting bare tops of less than 10% of total tree height. The plot trees that had died during the current outbreak had been influenced by other factors such as broken tops and root disease and probably did not die as a direct result of budworm defoliation. About half the trees exhibited light cumulative defoliation with 22% rated as moderate and 12% rated as heavy. Current defoliation was rated as heavy on 29% of the host trees with 29% in the "none" category. Defoliation has been evident at plot sites for 1 to 4 years.

Recommendations for 1989: No insecticide treatment; pay close attention to 1989 aerial survey; gather larval population density information in June using lower crown sampling techniques; do more intensive tree damage data collection and pheromone trapping if warranted by larval data.

WALLOWA-WHITMAN NATIONAL FOREST

Grossman

Pheromone trap catches predict light defoliation for 1989. No bare tops were observed on 93% of the host trees. Cumulative was rated as heavy on 70% of the host trees with 13% falling into the "none" category. The high percentage in the heavy cumulative defoliation category does not correlate with the bare top ratings. It is possible that the crew was not using the proper criteria for rating cumulative defoliation. Current defoliation was rated as heavy on 43% of the host trees and as "none" on almost half the trees. Defoliation has been evident at plot sites for 0 to 1 year.

Recommendations for 1989: No insecticide treatment; pay close attention to 1989 aerial survey; gather larval population density information in June using lower crown sampling techniques; do more intensive tree damage data collection and pheromone trapping if warranted by larval data.

Halfway

Pheromone trap catches predict patchy defoliation for 1989. No bare tops were observed on 77% of the trees with 19% having bare tops greater than 10% of crown height. All trees exhibited some cumulative defoliation with 24% rated as heavy, 55% as moderate, and 21% as light. These cumulative defoliation estimates were made by the same crew as those for Grossman AU and, thus, may be somewhat exaggerated. Current defoliation was rated as heavy on 42% of host trees and "none" to light on 41%. Defoliation has been evident at plot sites for 2 to 3 years.

Recommendations for 1989: No insecticide treatment; pay close attention to 1989 aerial survey; gather larval population density information in June using lower crown sampling techniques; do more intensive tree damage data collection and pheromone trapping if warranted by larval data.

South NRA

Pheromone trap catches predict light defoliation for 1989. No bare tops were observed on 73% of host trees with 24% having bare tops from 1% to 10% of crown height. Ninety-nine percent of host trees exhibited some cumulative defoliation with 65% rated as heavy, 31% as moderate, and 3% as light. These cumulative defoliation estimates were made by the same crew as those for Grossman AU and, thus, may be somewhat exaggerated. Current defoliation was rated as heavy on 36% of host trees and as "none" on a little over half the trees. Defoliation has been evident at plot sites for 0 to 2 years.

Recommendations for 1989: No insecticide treatment in 1989; pay close attention to 1989 aerial survey; gather larval population density information in June using lower crown sampling techniques; do more intensive tree damage data collection and pheromone trapping if warranted by larval data.

Wallowa

No pheromone traps were placed in this AU during 1988. No bare tops were observed on 66% of host trees with 19% having bare tops from 1% to 10% of total tree height. Of the 14% of host trees that were dead, almost all were in the 4-inch dbh class. Budworm defoliation has been detected in this AU for no more than three years and only 6% of the trees exhibited heavy cumulative defoliation. Therefore, it is doubtful that these trees died as a direct result of budworm defoliation. Cumulative defoliation was rated as light on over half of the host trees, while 27% were rated as "none". Current defoliation was rated as "none" on 66% of host trees, with 18% rated as light and 12% as heavy. Defoliation has been evident at plot sites for 2 to 3 years.

Recommendations for 1989: No insecticide treatment; pay close attention to 1989 aerial survey; gather larval population density information in June using lower crown sampling techniques; do more intensive tree damage data collection and pheromone trapping if warranted by larval data.

WILLAMETTE AND DESCHUTES NATIONAL FORESTS

Santiam

Pheromone trap catches predict light defoliation in 1989. No bare tops were observed on 56% of host trees with 38% exhibiting bare tops from 1% to 10% of total tree height. Cumulative defoliation was rated as light in nearly half the host trees, with 19% rated as "none", 18% as moderate, and 16% as heavy. Current defoliation was rate as "none" on 43% of host trees with 26% rated as light, 12% as moderate, as 19% as heavy. Defoliation has been evident at plot sites for 0 to 3 years.

Recommendations for 1989: Do not treat whole AU with insecticides. However, if resource values are high enough, treatment may be warranted for several areas within the AU which have exhibited heavy defoliation for two or three years. If there is no insecticide treatment, pay close attention to 1989 aerial survey; gather larval population density information in June using lower crown sampling techniques; do more intensive tree damage data collection and pheromone trapping if warranted by larval data.

WILLAMETTE NATIONAL FOREST

Big Meadows

Pheromone trap catches predict light defoliation in 1989. No bare tops were observed on 95% of the host trees. Cumulative defoliation was rated as light on 9% of host trees and as "none" on the remaining 91%. Current defoliation was rated as "none" on 69% of host trees, light on 21%, and heavy on only 4%. Defoliation has been evident at plot sites for 0 to 3 years.

Recommendations for 1989: No insecticide treatment in 1989; pay close attention to 1989 aerial survey; gather larval population density information in June using lower crown sampling techniques; do more intensive tree damage data collection and pheromone trapping if warranted by larval data.

YAKIMA INDIAN RESERVATION

Simcoe

No pheromone traps were placed in this AU during 1988. However, about 90 pheromone traps were placed in adjacent or nearby private lands by the Washington Department of Natural Resources (WDNR). The average catch was somewhere between 20 and 30 moths per trap (Rick Johnsey, WDNR, personal communication), indicating light defoliation for 1989. In addition, average 1988 egg mass densities for these private lands were about 85% lower than those of 1987 (Rick Johnsey, WDNR, personal communication).

No bare tops were observed on 63% of host trees, with 35% exhibiting bare top from 1% to 10% of total tree height. Only 3% of the host trees had a cumulative defoliation rating of heavy, while 55% were rated as light, and 38% as "none". Current defoliation was rated as heavy on 80% of the host trees while 11% were rated as "none", and 4% as light. Defoliation has been evident at plot sites for 0 to 5 years.

Recommendations for 1989: No insecticide treatment in 1989; pay close attention to 1989 aerial survey; gather larval population density information in June using lower crown sampling techniques; do more intensive tree damage data collection and pheromone trapping if warranted by larval data.

Signal Peak

No pheromone traps were placed in this AU during 1988. The pheromone trap and egg mass information collected by the Washington Department of Natural Resources near Simcoe AU may be relevant to this AU also. No Bare tops were observed on 58% of host trees. The remainder of the host trees exhibited bare tops from 1% to 10% of total tree height. Cumulative defoliation was rated as "none" or light on 97% of host trees with no trees being placed into the heavy category. Current defoliation was rated as heavy on half the host trees with 43% falling in the "none" or light. Defoliation has been evident at plot sites for 0 to 4 years.

Recommendations for 1989: No insecticide treatment in 1989; pay close attention to 1989 aerial survey; gather larval population density information in June using lower crown sampling techniques; do more intensive tree damage data collection and pheromone trapping if warranted by larval data.

In the Pacific Northwest Region, the area of budworm defoliation detected by the aerial survey has dropped significantly from 1987 to 1988. In addition, defoliation for 1989 is not predicted to be greater than light on any of the AUs sampled using pheromone traps. Thus, from a biological standpoint, it is recommended that managers apply insecticides in 1989 on either none or very few of the acres being considered formally in the environmental analysis. If some budworm suppression is done in 1989, it is recommended that it be done in those areas where the adverse effects on the resources would be the greatest if the 1989 budworm population levels are higher than predicted. It is also recommended that budworm population and tree damage sampling be intensified in areas not treated with insecticides in 1989.

Table 1. Analysis Unit names, land manager, and type of data collected, 1988 western spruce budworm biological evaluation, Pacific Northwest Region.

Land Manager	Analysis Unit[1]	Pheromone Trap	Tree Damage
Deschutes NF	*Bluegrass	Y	Y
	*Sheep Springs	Y	Y
	*Metolius	Y	Y
Malheur NF	Flat	Y	N
	Lost Cabin	Y	N
	Reynolds	Y	Y
Mt. Hood NF	*High Rock	Y	Y
	Clackamas	Y	Y
Umatilla NF	*Thimbleberry	Y	Y
	Squaw	Y	Y
	Mill	Y	Y
	Watershed	Y	Y
	Target	Y	Y
Wallowa-Whitman NF	*Grossman	Y	Y
	*Halfway	Y	Y
	*South NRA	Y	Y
	*Wallowa	N	Y
Willamette NF & Deschutes NF	*Santiam	Y	Y
Willamette NF	*Big Meadows	Y	Y
Yakima IR	*Simcoe	N	Y
	*Signal Peak	N	Y

[1]Analysis Units which are being considered formally in the environmental analysis are preceded by an asterisk.

Table 2. Average numbers of western spruce budworm moths per pheromone trap captured in Pacific Northwest Region, 1988.

Analysis Unit[1]	No. of Traps	Moths per Trap	Predicted 1989 Defoliation[2]
*Bluegrass	14	31.2 ± 3.5	L
*Sheep Springs	19	31.7 ± 1.7	L
*Metolius	20	23.1 ± 2.3	L
Flat	33	21.7 ± 2.4	L
Lost Cabin	34	18.9 ± 2.2	P
Reynolds	30	24.0 ± 2.1	L
*High Rock	23	8.1 ± 1.8	P
Clackamas	45	1.5 ± 0.5	U
*Thimbleberry	25	20.7 ± 2.2	L
Squaw	28	9.3 ± 2.7	P
Mill	21	11.2 ± 2.8	P
Watershed	25	13.1 ± 1.9	P
Target	20	22.6 ± 3.6	L
*Grossman	25	23.8 ± 2.1	L
*Halfway	28	17.9 ± 1.9	P
*South NRA	28	19.8 ± 2.9	L
*Wallowa		NO DATA	
*Santiam	14	31.3 ± 1.8	L
*Big Meadows	10	28.0 ± 4.4	L
*Simcoe		NO DATA	
*Signal Peak		NO DATA	

[1] Analysis Units which are being considered formally in the environmental analysis are preceded by an asterisk.

[2] U = defoliation undetectable by cursory observation; P = patchy defoliation within some trees; and L = most trees lightly defoliated

Table 3. Percent host trees/acre that are green, have 1-10% bare top, have >10% bare top, and are dead, 1988 western spruce budworm biological evaluation, Pacific Northwest Region.

Analysis Unit[1]	Green	1-10% Bare Top	>10% Bare Top	Dead
*Bluegrass	100	0	0	0
*Sheep Springs	67	25	8	0
*Metolius	99	0	1	0
Flat	N/A			
Lost Cabin	N/A			
Reynolds[2]	67	21	11	1
*High Rock	97	3	0	0
Clackamas	N/A			
*Thimbleberry	87	8	0	5
Squaw	99	0	1	0
Mill	99	1	0	0
Watershed	78	15	5	0
Target	97	3	0	0
*Grossman	93	7	0	0
*Halfway[2]	77	4	19	0
*South NRA[2]	73	24	3	0
*Wallowa	66	19	1	14
*Santiam	56	38	6	0
*Big Meadows	95	5	0	0
*Simcoe	63	35	1	1
*Signal Peak	58	42	0	0

[1] Analysis Units which are being considered formally in the environmental analysis are preceded by an asterisk.

[2] Bare top values for these AUs were calculated as a percentage of crown height, not as a percentage of total tree height as was done in the other AUs.

Table 4. Percent host trees/acre by missing foliage (i.e., total cumulative defoliation) class, 1988 western spruce budworm biological evaluation, Pacific Northwest Region.

Analysis Unit[1]	None	Light	Moderate	Heavy
*Bluegrass	46	54	0	0
*Sheep Springs	39	17	26	18
*Metolius	22	34	43	1
Flat	N/A			
Lost Cabin	N/A			
Reynolds	0	0	16	84
*High Rock	84	16	0	0
Clackamas	N/A			
*Thimbleberry	6	60	22	12
Squaw	35	13	6	46
Mill	89	11	0	0
Watershed	51	49	0	0
Target	81	16	3	0
*Grossman	13	9	8	70
*Halfway	0	21	55	24
*South NRA	1	3	31	65
*Wallowa	27	56	11	6
*Santiam	19	47	18	16
*Big Meadows	91	9	0	0
*Simcoe	38	55	4	3
*Signal Peak	55	42	3	0

[1]Analysis Units which are being considered formally in the environmental analysis are preceded by an asterisk.

Table 5. Percent host trees/acre by current defoliation class, 1988 western spruce budworm biological evaluation, Pacific Northwest Region.

Analysis Unit[1]	None	Light	Moderate	Heavy
*Bluegrass	24	76	0	0
*Sheep Springs	21	13	8	58
*Metolius	4	54	4	38
Flat	N/A			
Lost Cabin	N/A			
Reynolds	0	9	12	69
*High Rock	73	1	2	24
Clackamas	N/A			
*Thimbleberry	29	18	24	29
Squaw	97	3	0	0
Mill	87	13	0	0
Watershed	61	39	0	0
Target	76	24	0	0
*Grossman	48	6	3	43
*Halfway	13	28	17	42
*South NRA	52	9	3	36
*Wallowa	66	18	4	12
*Santiam	43	26	12	19
*Big Meadows	69	21	6	4
*Simcoe	11	4	5	80
*Signal Peak	27	16	7	50

[1] Analysis Units which are being considered formally in the environmental analysis are preceded by an asterisk.

Table 6. Percent of trees in plots in each Analysis Unit that were budworm host species (i.e., Douglas-fir or Abies sp.), 1988 western spruce budworm biological evaluation, Pacific Northwest Region.

Analysis Unit[1]	No. of Plots	% Host (BA/A)	% Host (T/A)	QMD (in)
*Bluegrass	5	54	75	9.6
*Sheep Springs	6	78	86	12.1
*Metolius	6	85	94	7.5
Flat	N/A			
Lost Cabin	N/A			
Reynolds	10	74	73	8.6
*High Rock	9	69	92	6.8
Clackamas	N/A			
*Thimbleberry	9	88	95	14.5
Squaw	9	78	79	13.0
Mill	9	69	75	10.6
Watershed	8	84	94	8.9
Target	9	64	61	11.6
*Grossman	10	83	84	7.7
*Halfway	10	88	82	13.4
*South NRA	10	76	85	12.3
*Wallowa	10	76	74	12.1
*Santiam	10	76	73	11.4
*Big Meadows	8	73	73	13.7
*Simcoe	36	88	89	12.6
*Signal Peak	21	76	83	12.6

[1]Analysis Units which are being considered formally in the environmental analysis are preceded by an asterisk.

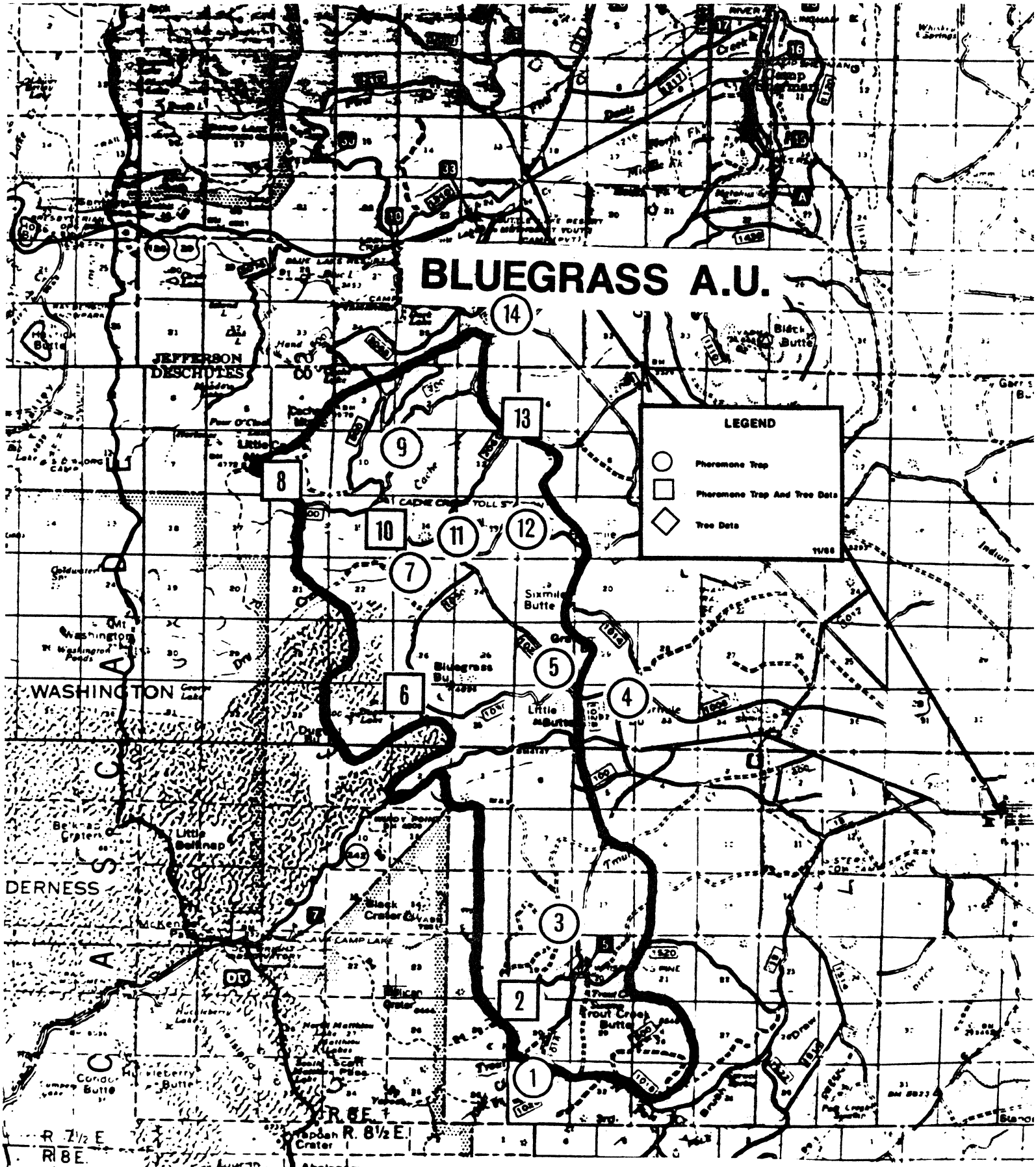


Figure 1. Bluegrass Analysis Unit, 1988 western spruce budworm biological evaluation, Deschutes National Forest.

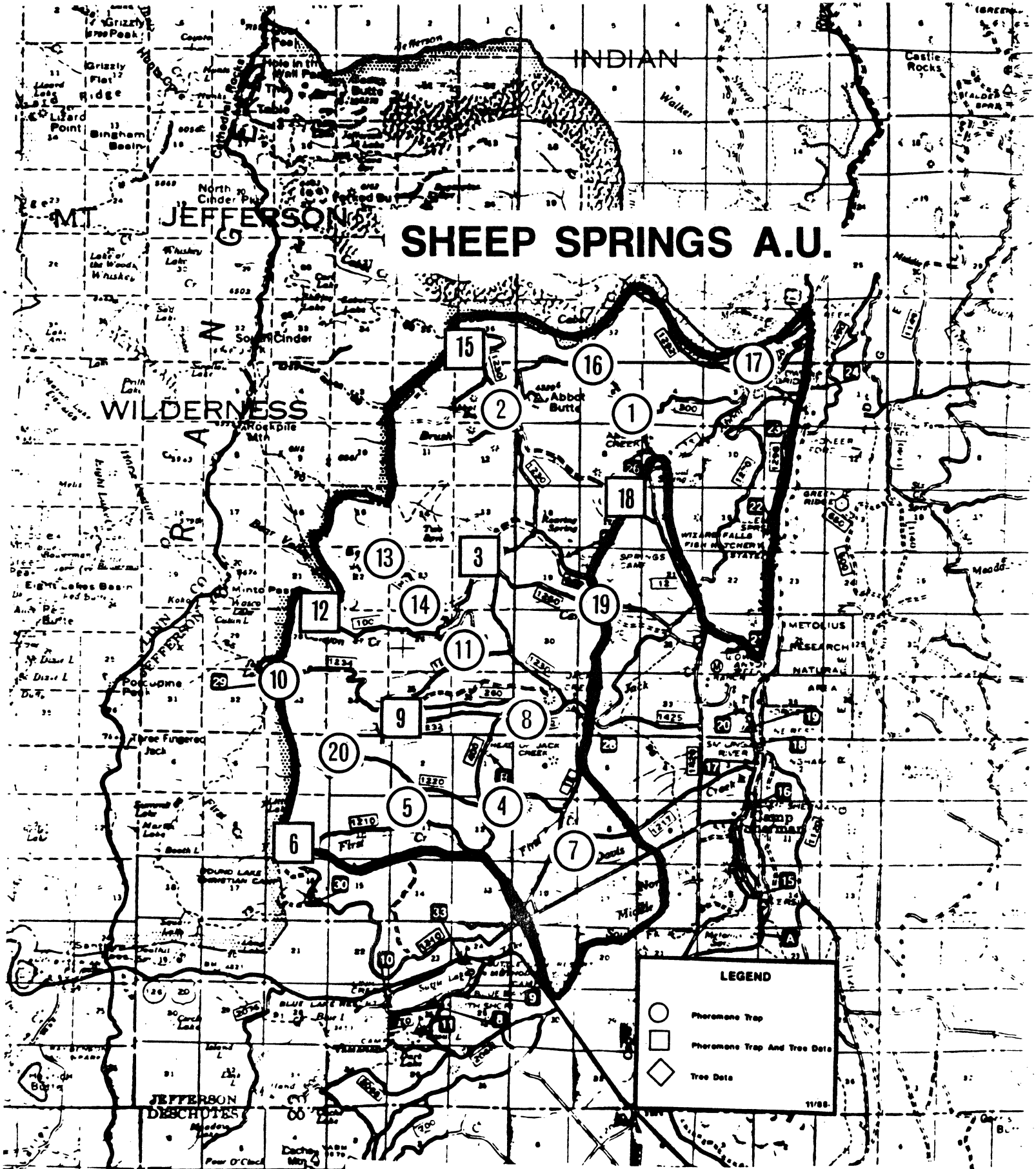


Figure 2. Sheep Springs Analysis Unit, 1988 western spruce budworm biological evaluation, Deschutes National Forest.

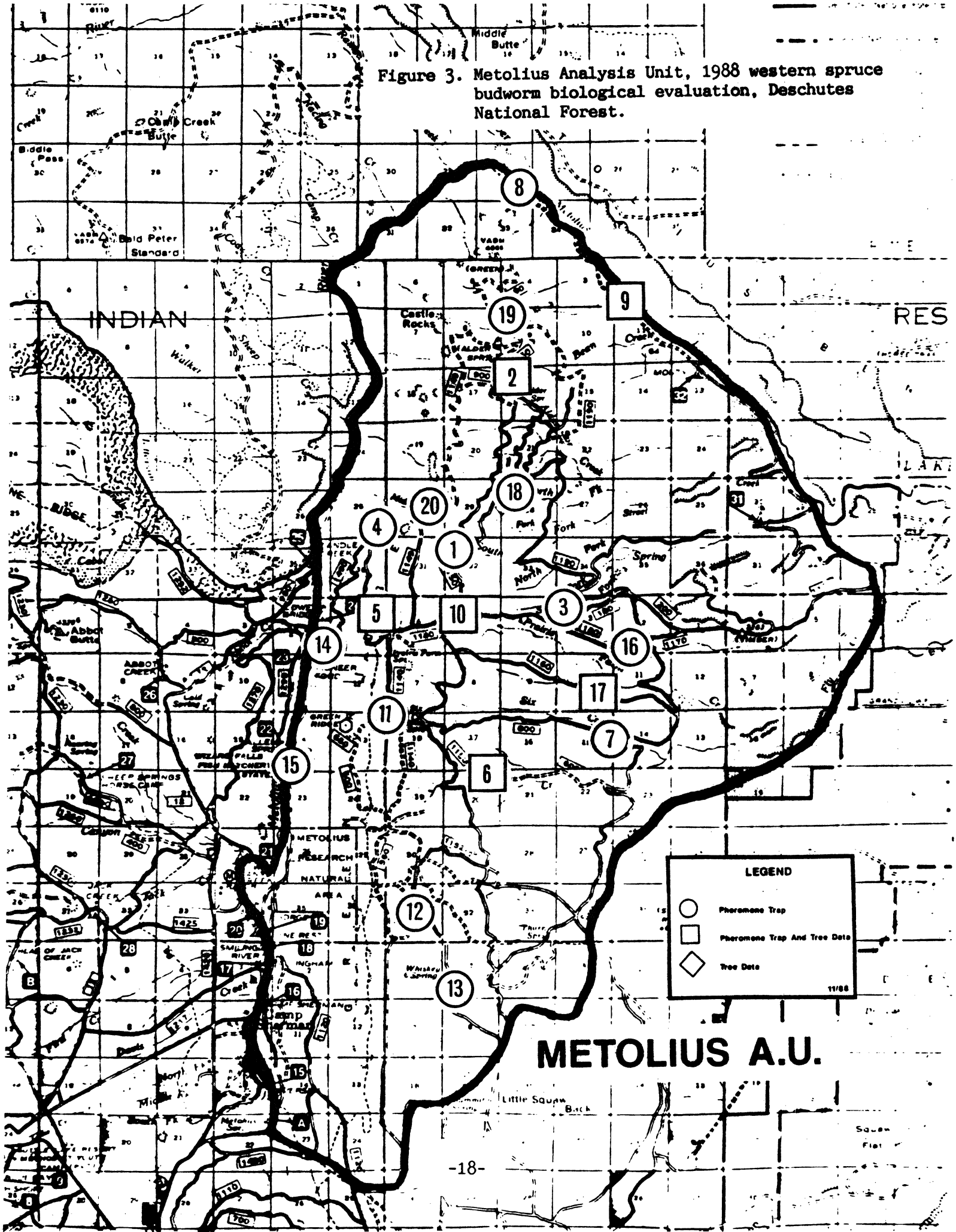


Figure 3. Metolius Analysis Unit, 1988 western spruce budworm biological evaluation, Deschutes National Forest.

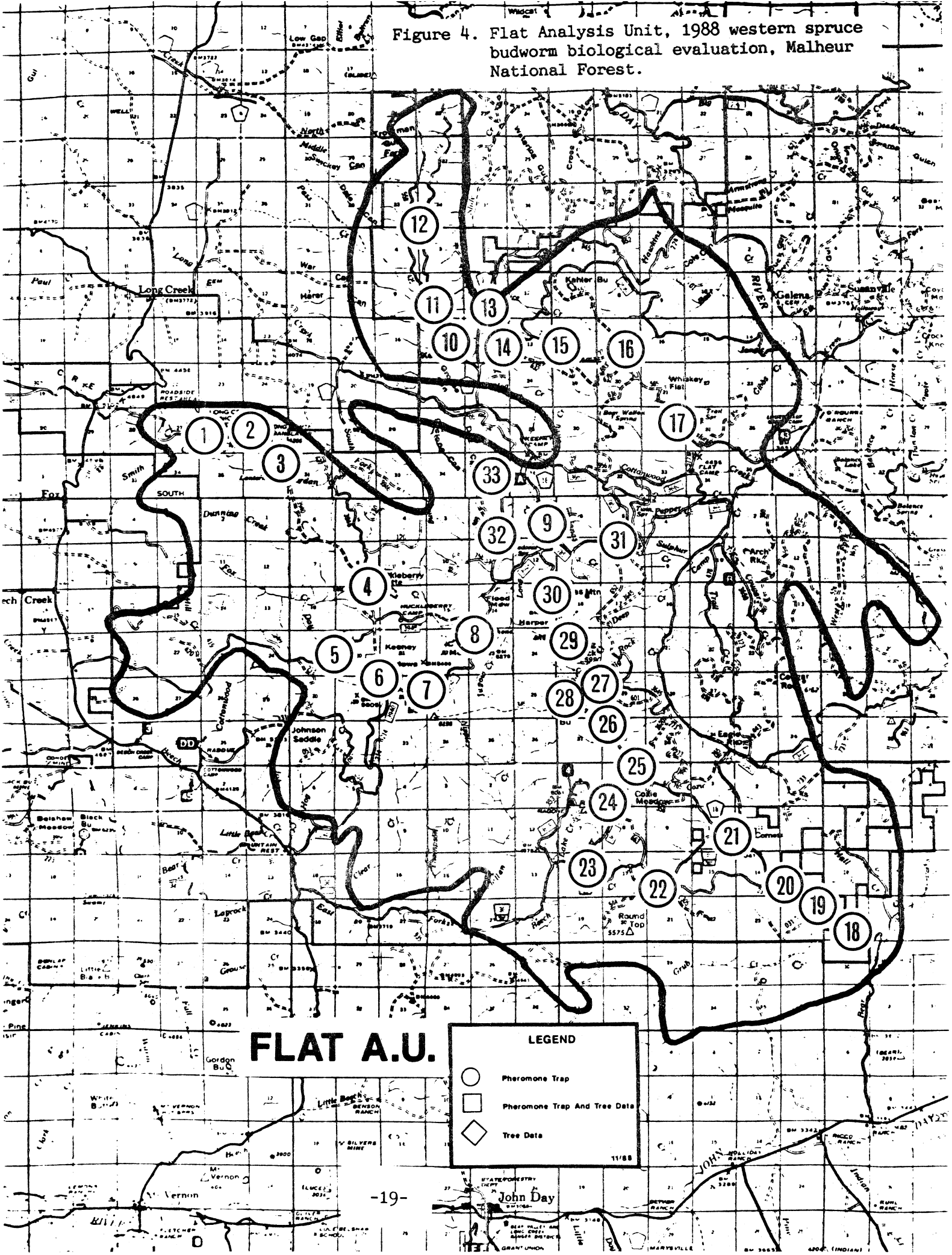


Figure 4. Flat Analysis Unit, 1988 western spruce budworm biological evaluation, Malheur National Forest.

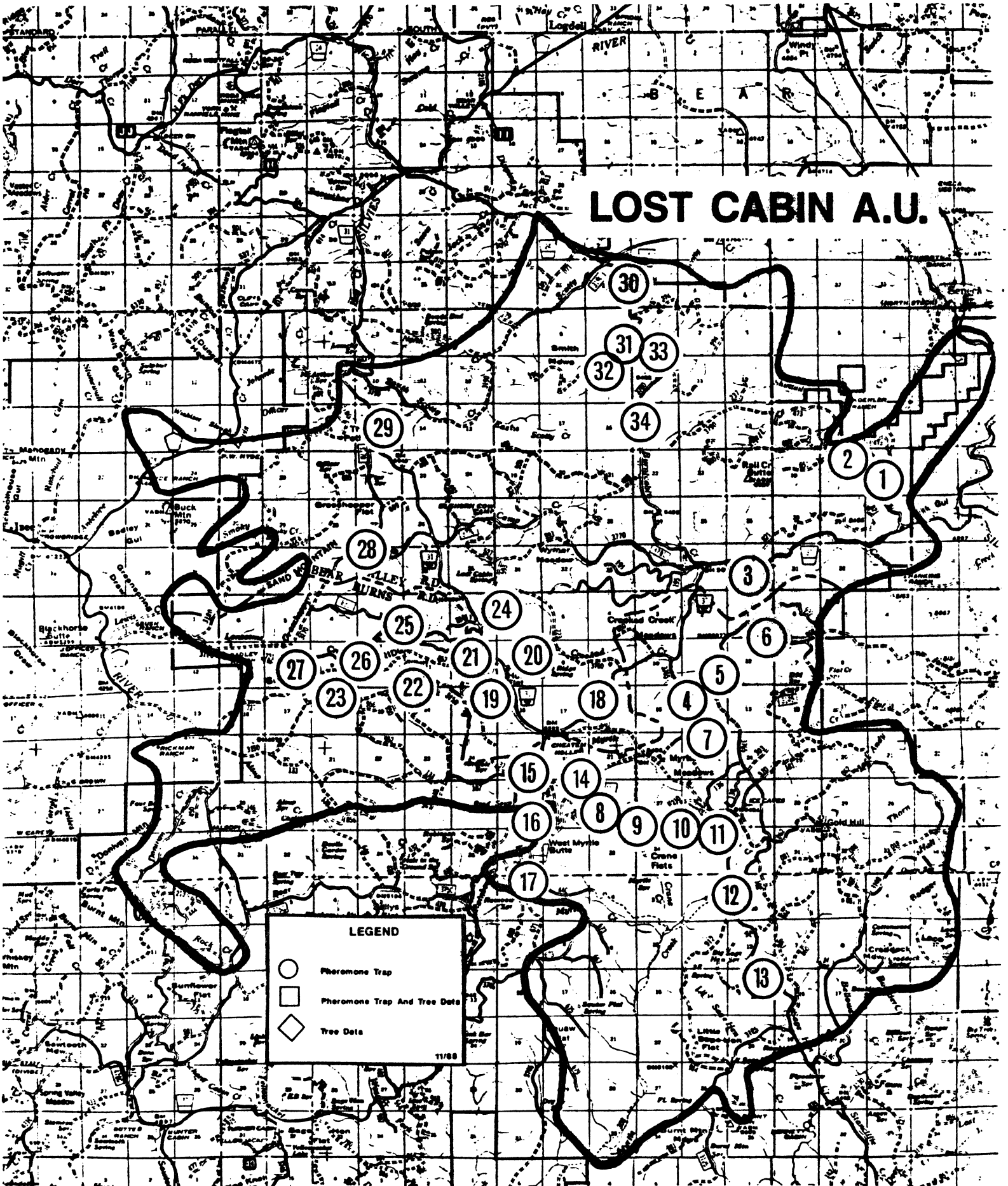


Figure 5. Lost Cabin Analysis Unit, 1988 western spruce budworm biological evaluation, Malheur National Forest.

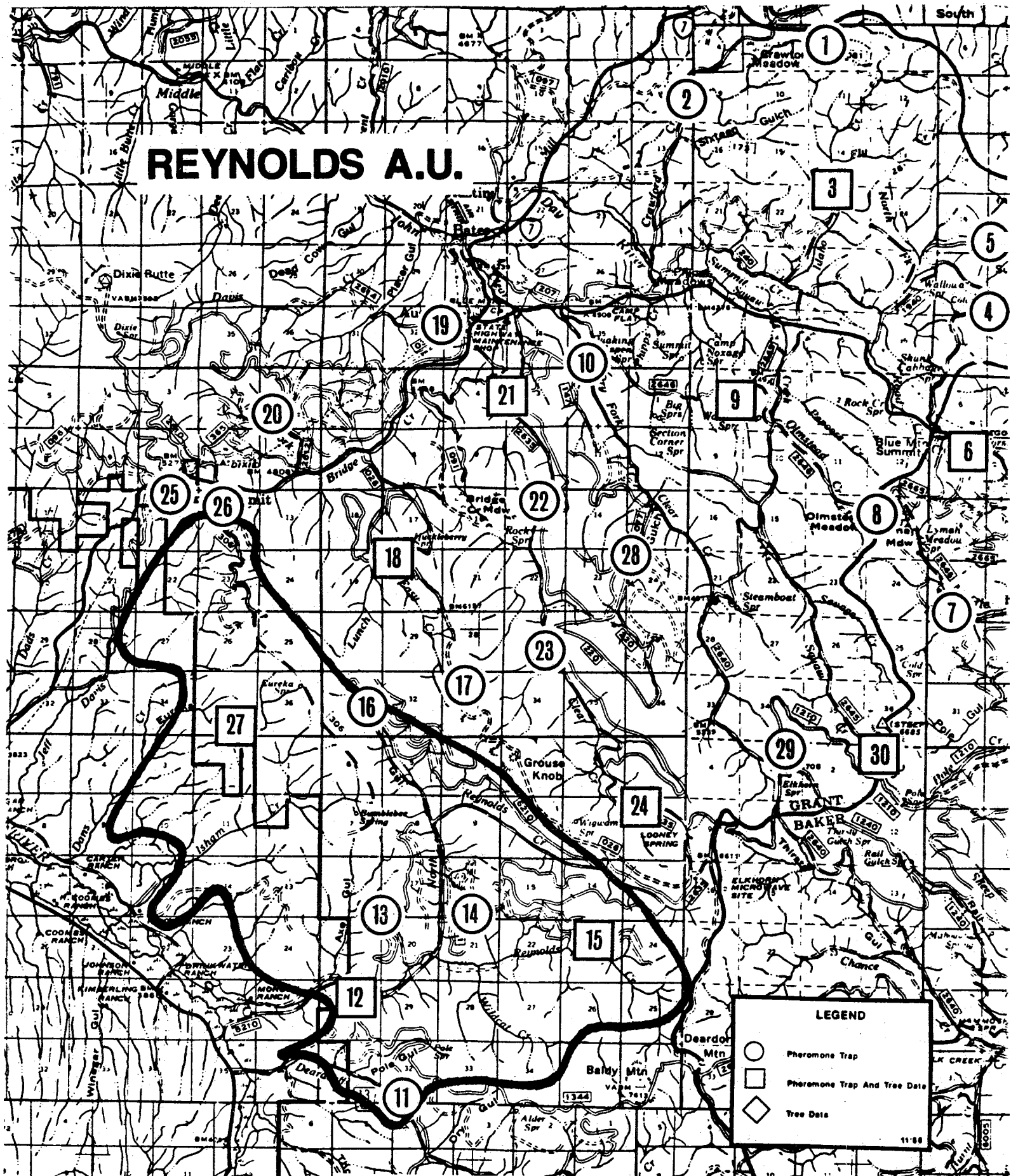


Figure 6. Reynolds Analysis Unit, 1988 western spruce budworm biological evaluation, Malheur National Forest.

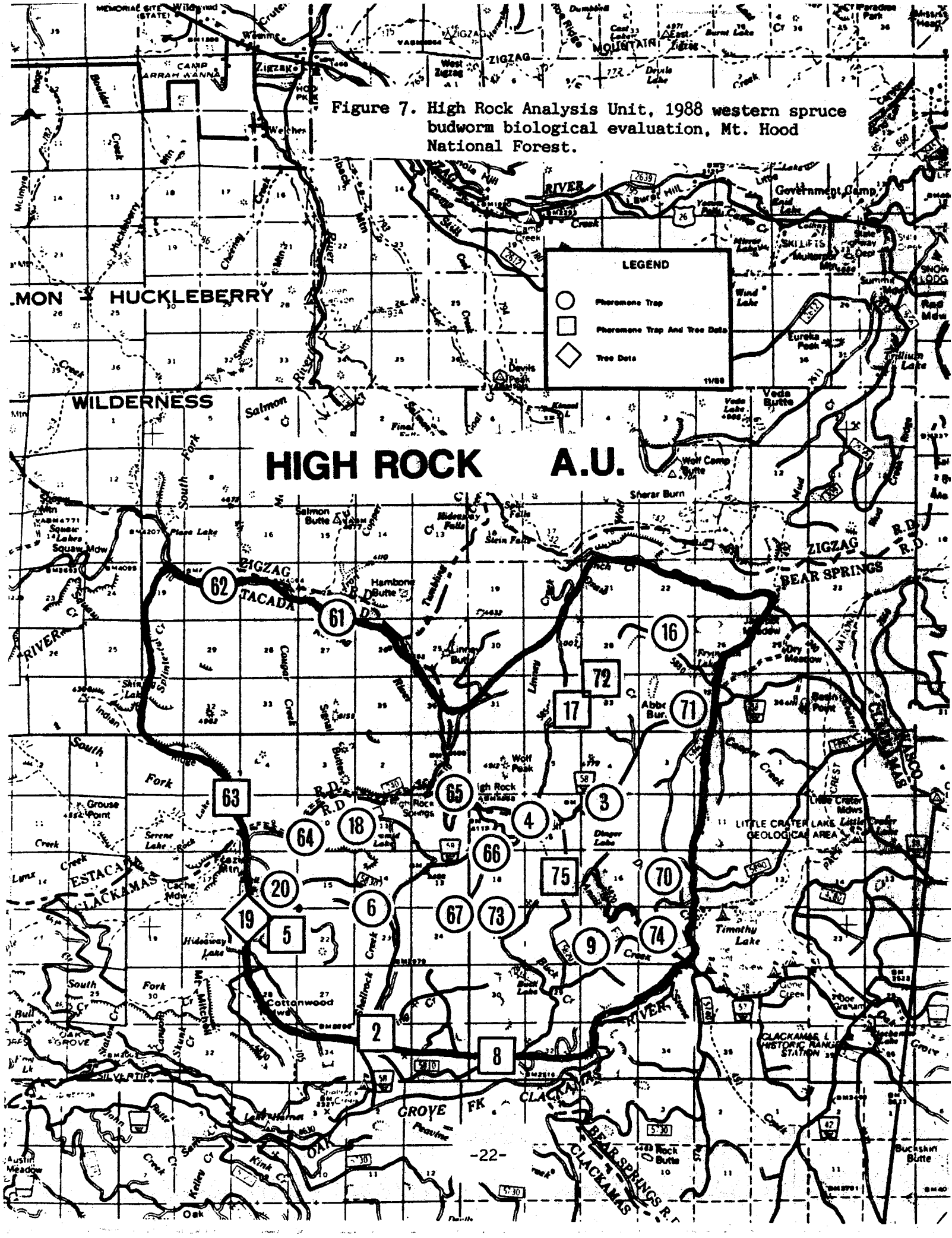


Figure 7. High Rock Analysis Unit, 1988 western spruce budworm biological evaluation, Mt. Hood National Forest.

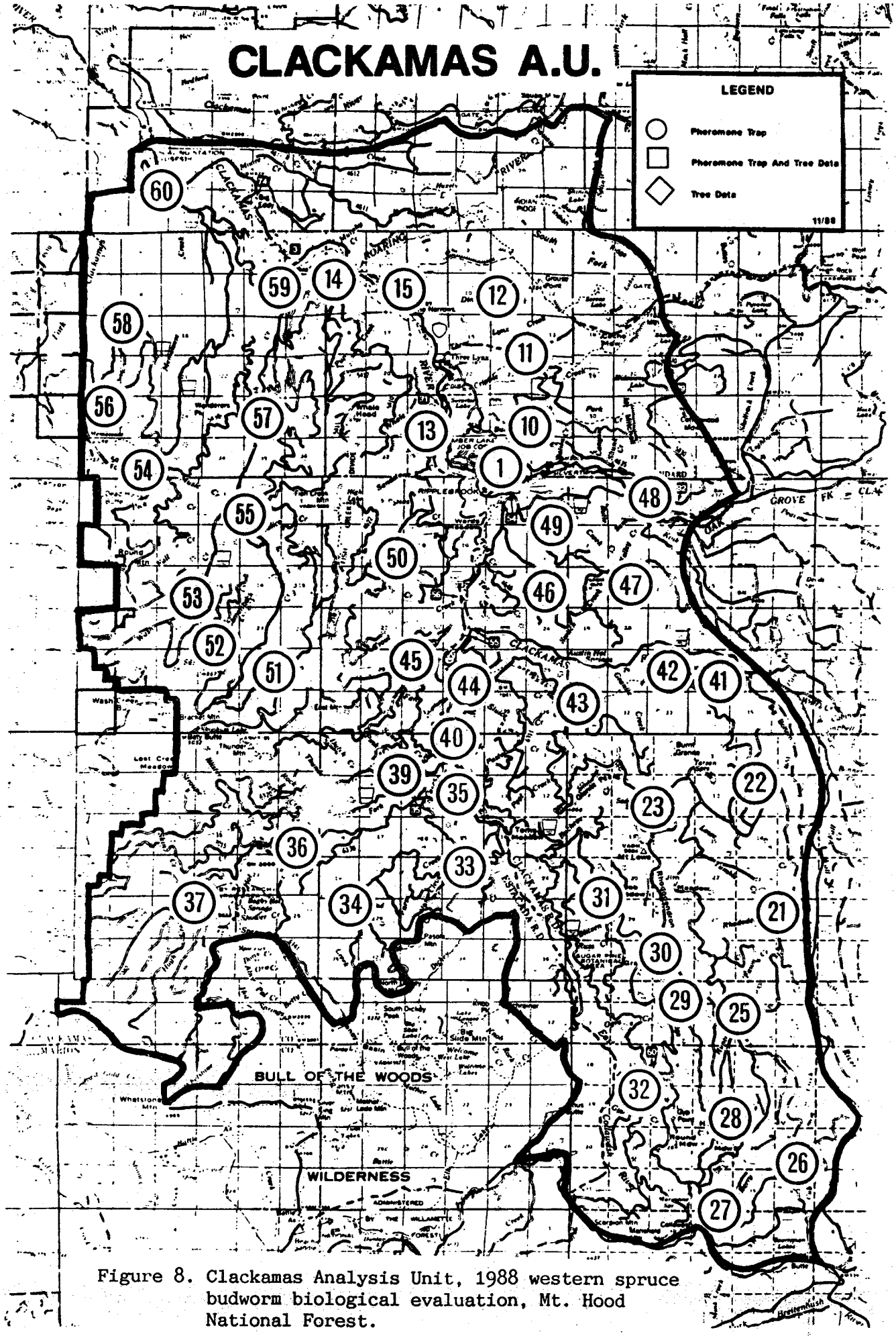


Figure 8. Clackamas Analysis Unit, 1988 western spruce budworm biological evaluation, Mt. Hood National Forest.

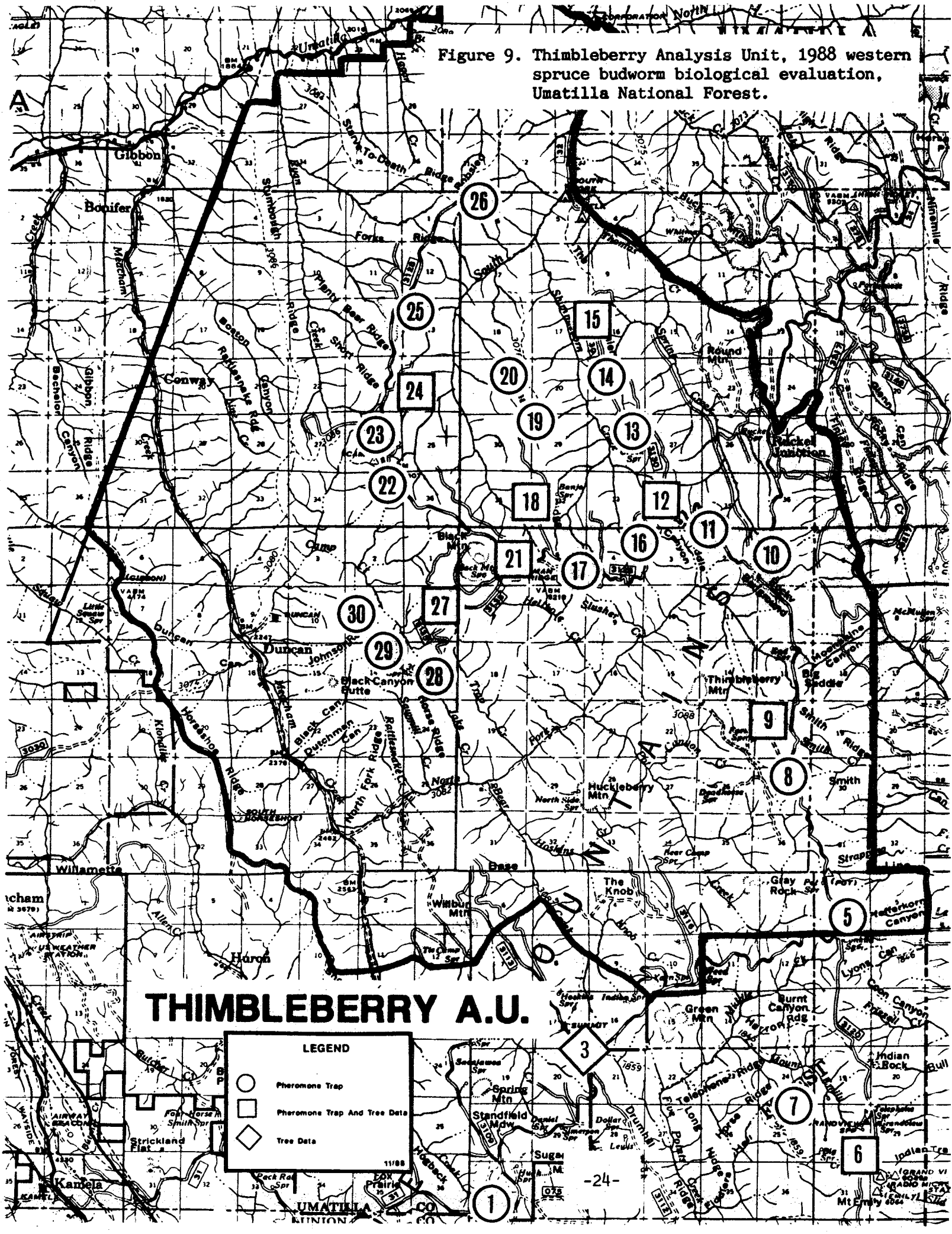
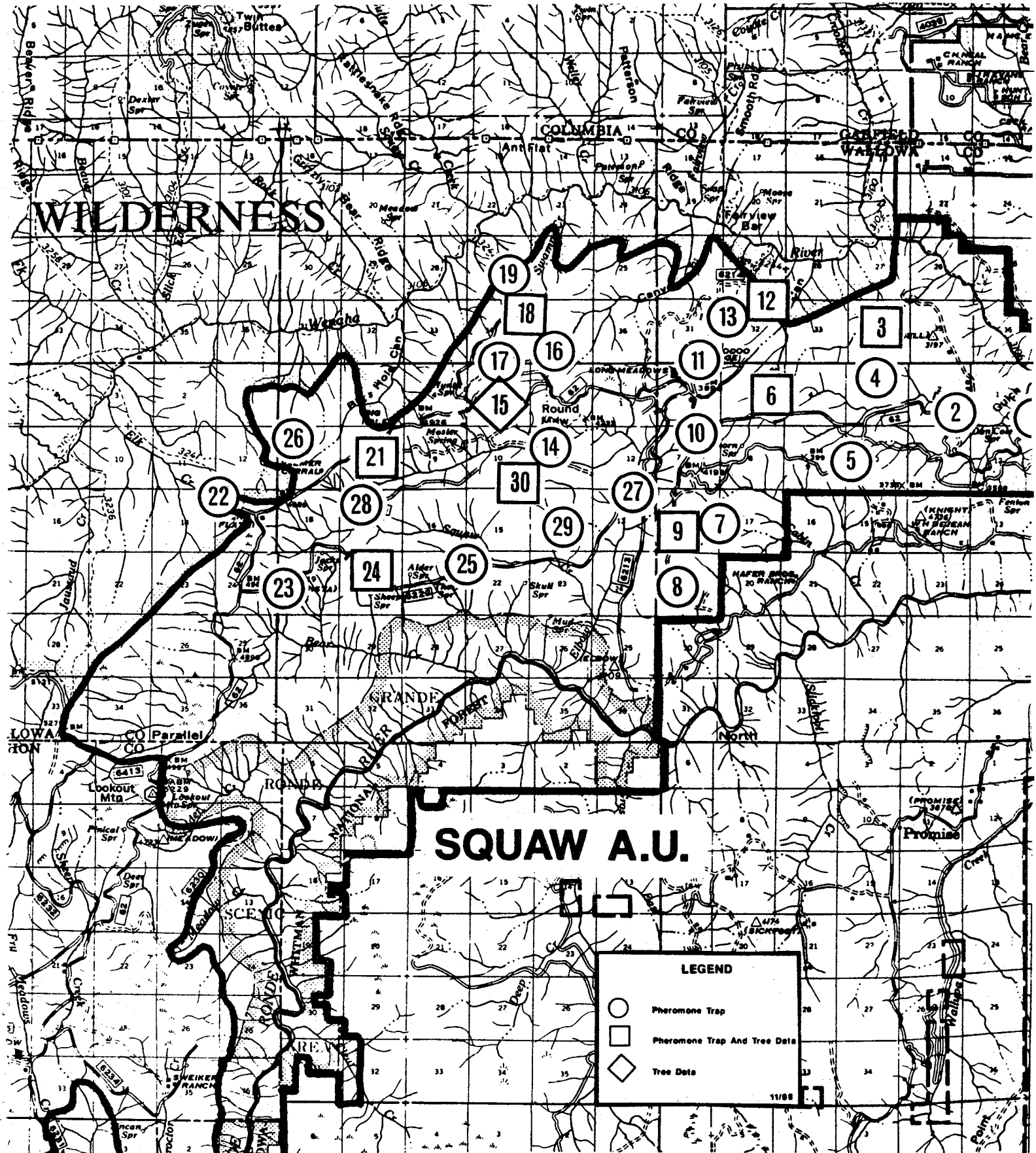


Figure 9. Thimbleberry Analysis Unit, 1988 western spruce budworm biological evaluation, Umatilla National Forest.


WILDERNESS
SQUAW A.U.
LEGEND
Pheromone Trap
Pheromone Trap And Tree Data
Tree Data
11/88
COLUMBIA CO
GARFIELD CO
WALLOWA CO
CO Parallel
Lookout Mtn
Promise
Maxville
Rondowa
Howard Mdw
Howard Bu
Round Mdw
LONG MEADOWS
GRANDE RONDE RIVER
NATIONAL WILD & SCENIC
Ant Flat
Twin Buttes
Rattlesnake Ridge
Bear Ridge
Fairview Bar
Bearwallow Spr
Meadow Spr
Deer Spr
Alder Spr
Skull Spr
Mud Spr
Fenton Spr
Jackson Spr
Sheep Spr
Pinical Spr
Deep Spr
Incan Spr
Middle Point
Wallupa
Deep
Proctor
Howard
Creek
Ridge
Canyon
Meadow
Mdw
Spr
Cr
Ck
Rd
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Fork
Point
Wallupa
Deep
Proctor
Howard
Creek
Ridge

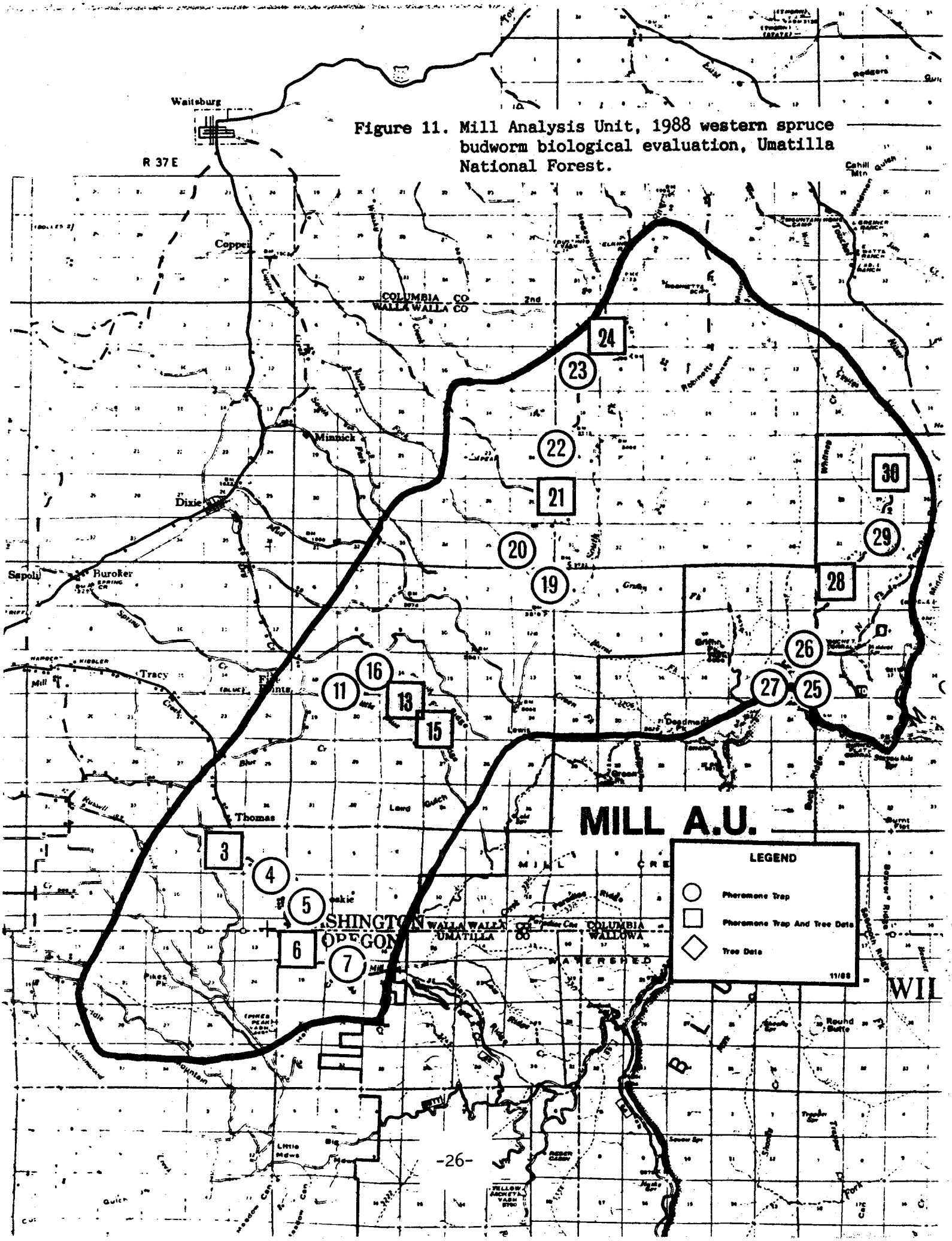


Figure 11. Mill Analysis Unit, 1988 western spruce budworm biological evaluation, Umatilla National Forest.

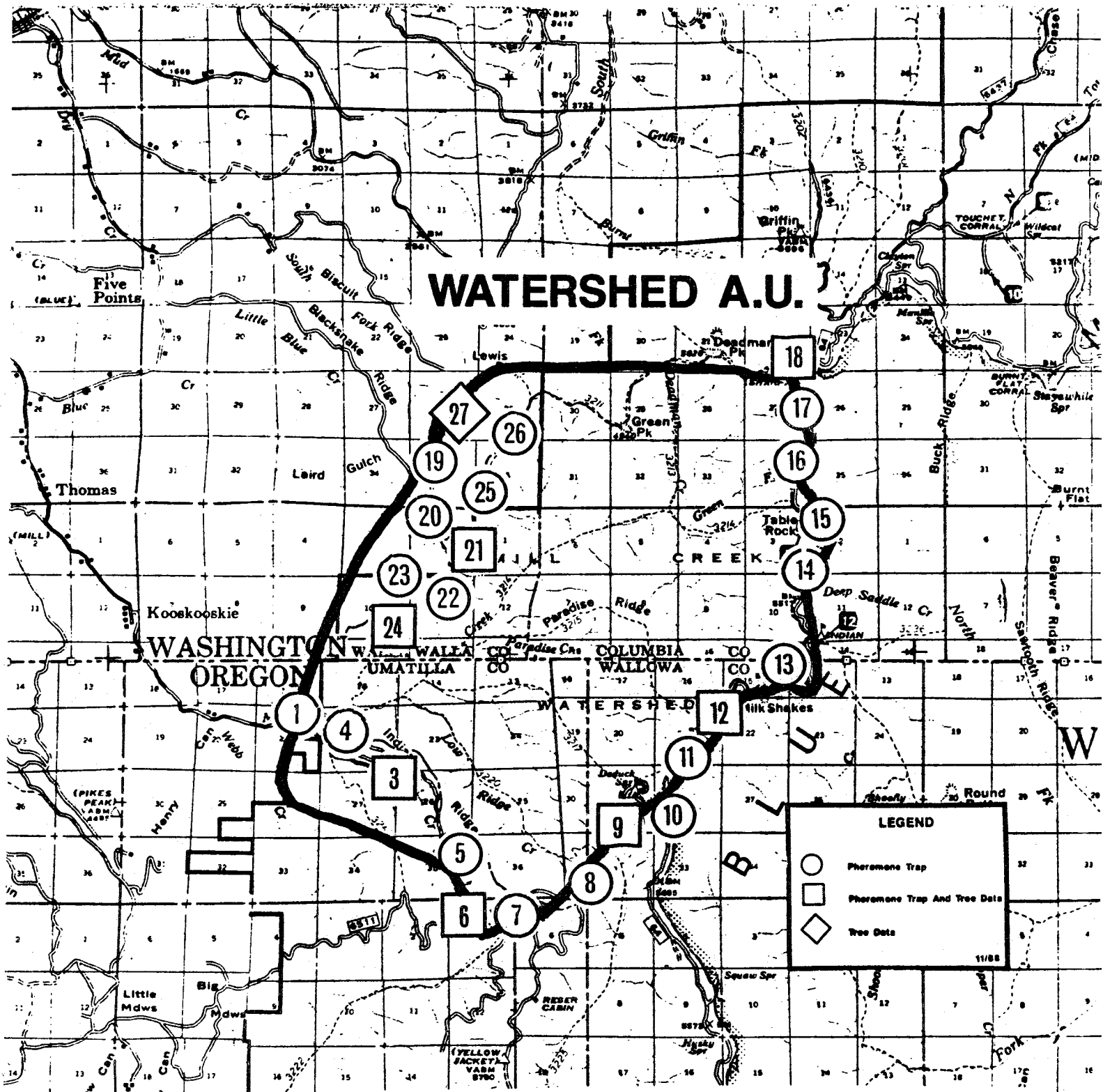


Figure 12. Watershed Analysis Unit, 1988 western spruce budworm biological evaluation, Umatilla National Forest.

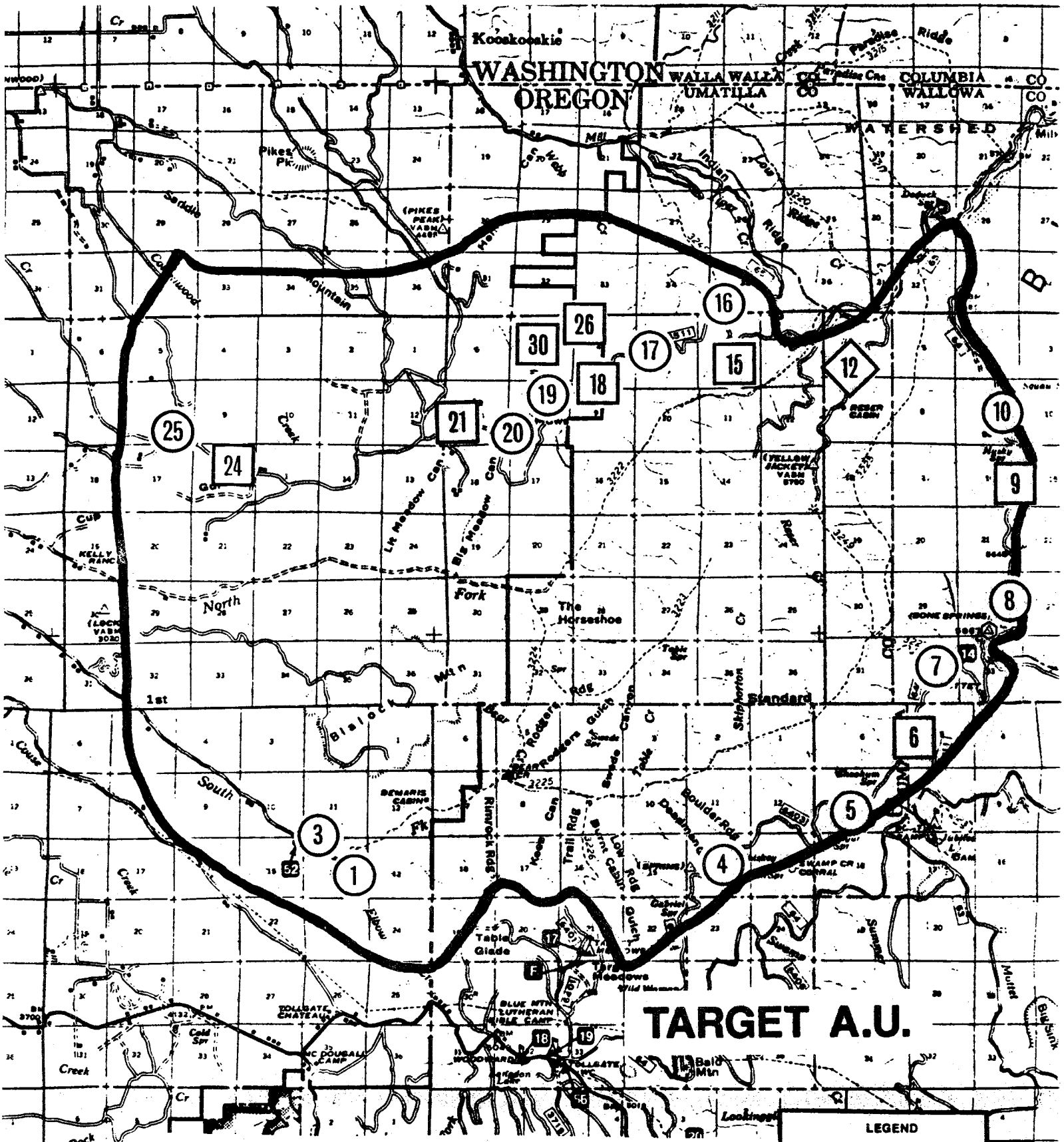
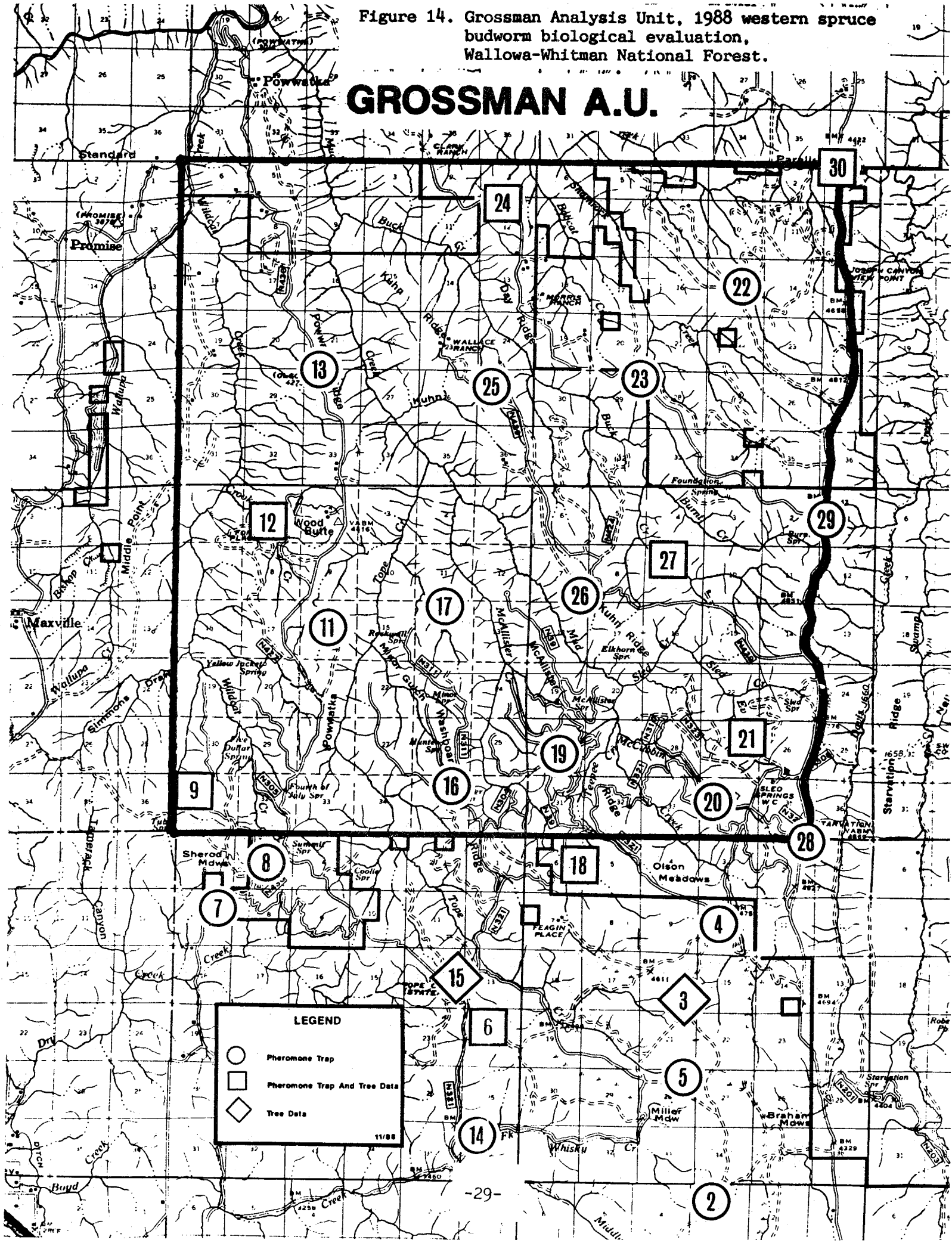


Figure 13. Target Analysis Unit, 1988 western spruce budworm biological evaluation, Umatilla National Forest.

Figure 14. Grossman Analysis Unit, 1988 western spruce budworm biological evaluation, Wallowa-Whitman National Forest.



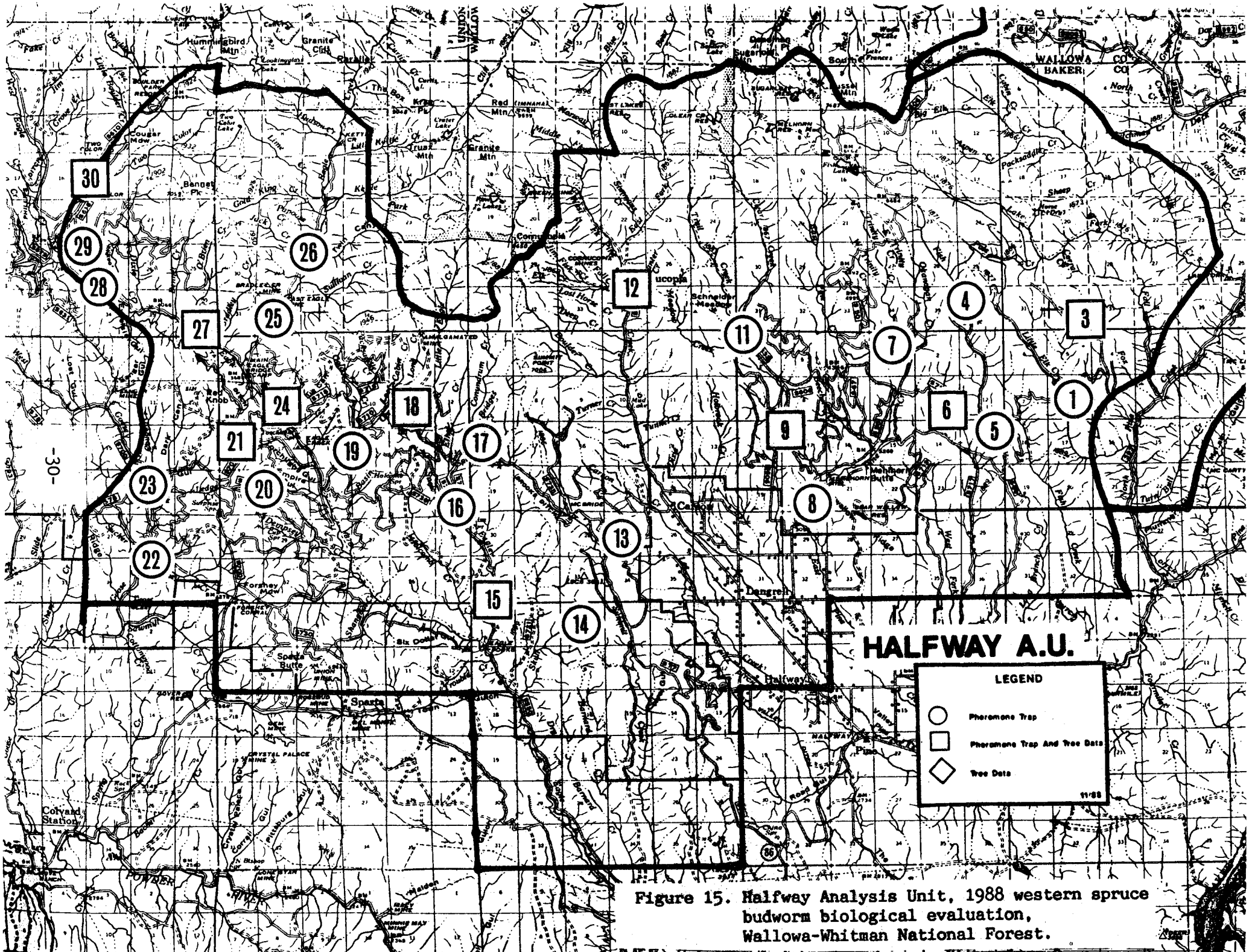
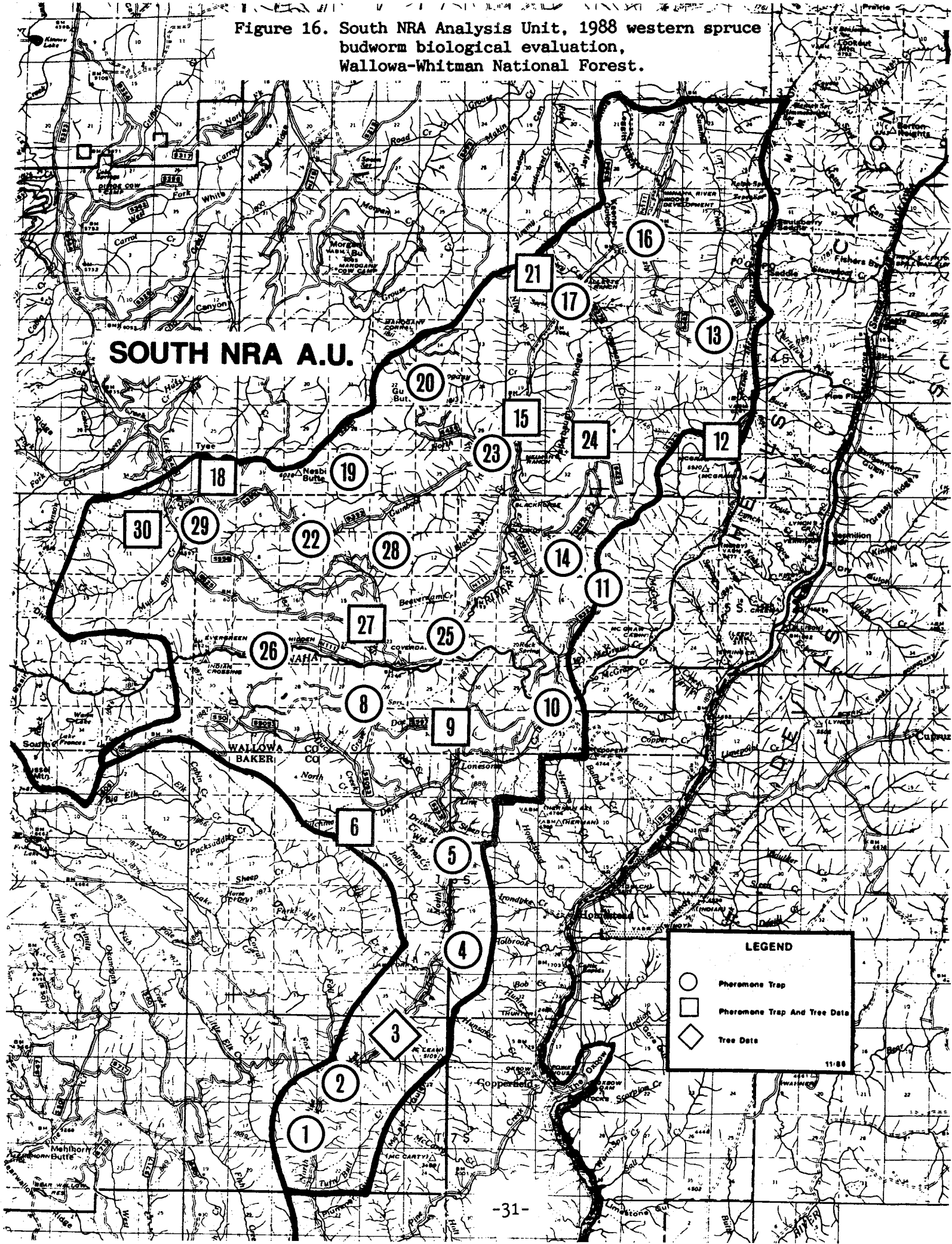


Figure 15. Halfway Analysis Unit, 1988 western spruce budworm biological evaluation, Wallowa-Whitman National Forest.

Figure 16. South NRA Analysis Unit, 1988 western spruce budworm biological evaluation, Wallowa-Whitman National Forest.



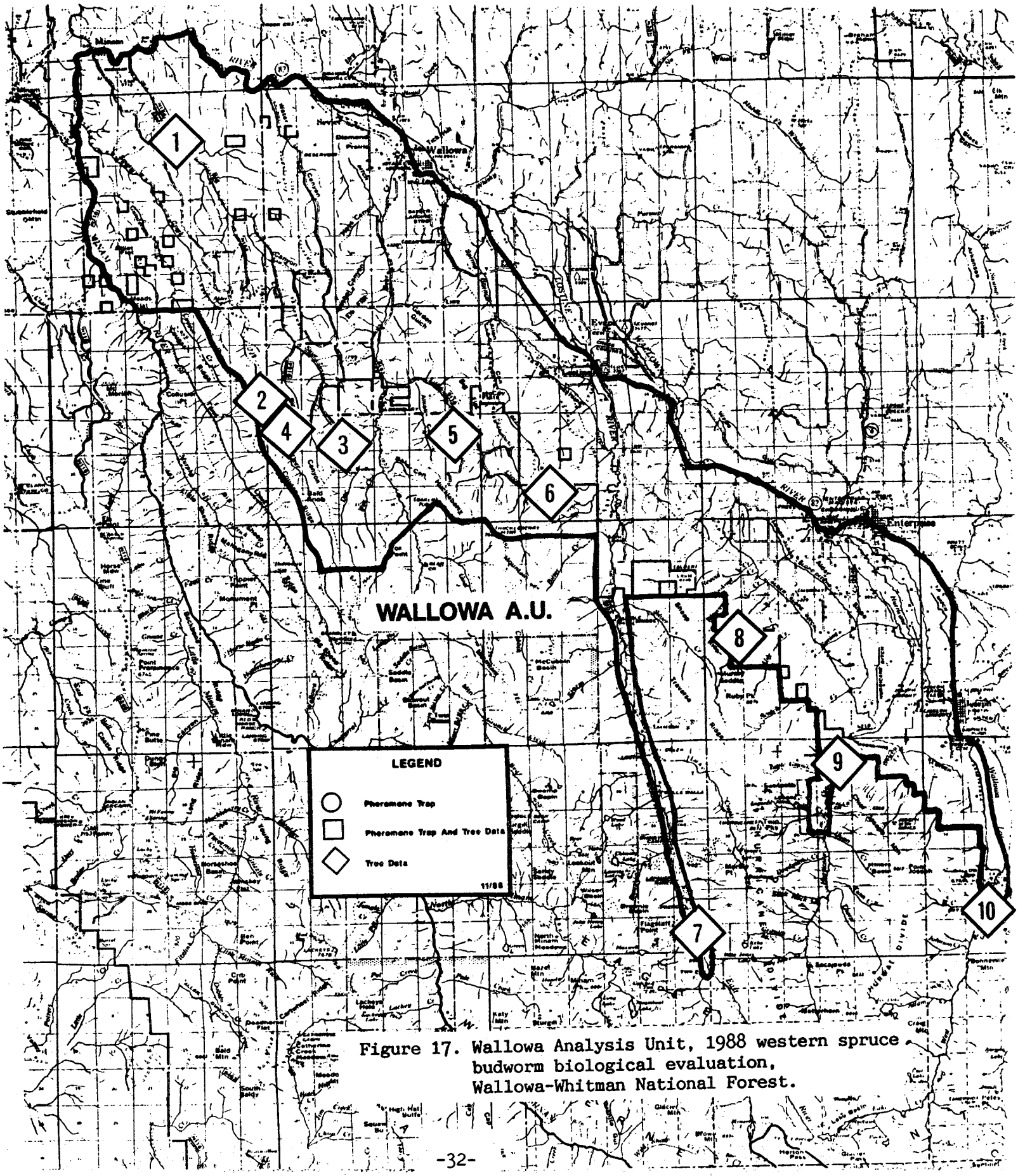


Figure 17. Wallowa Analysis Unit, 1988 western spruce budworm biological evaluation, Wallowa-Whitman National Forest.

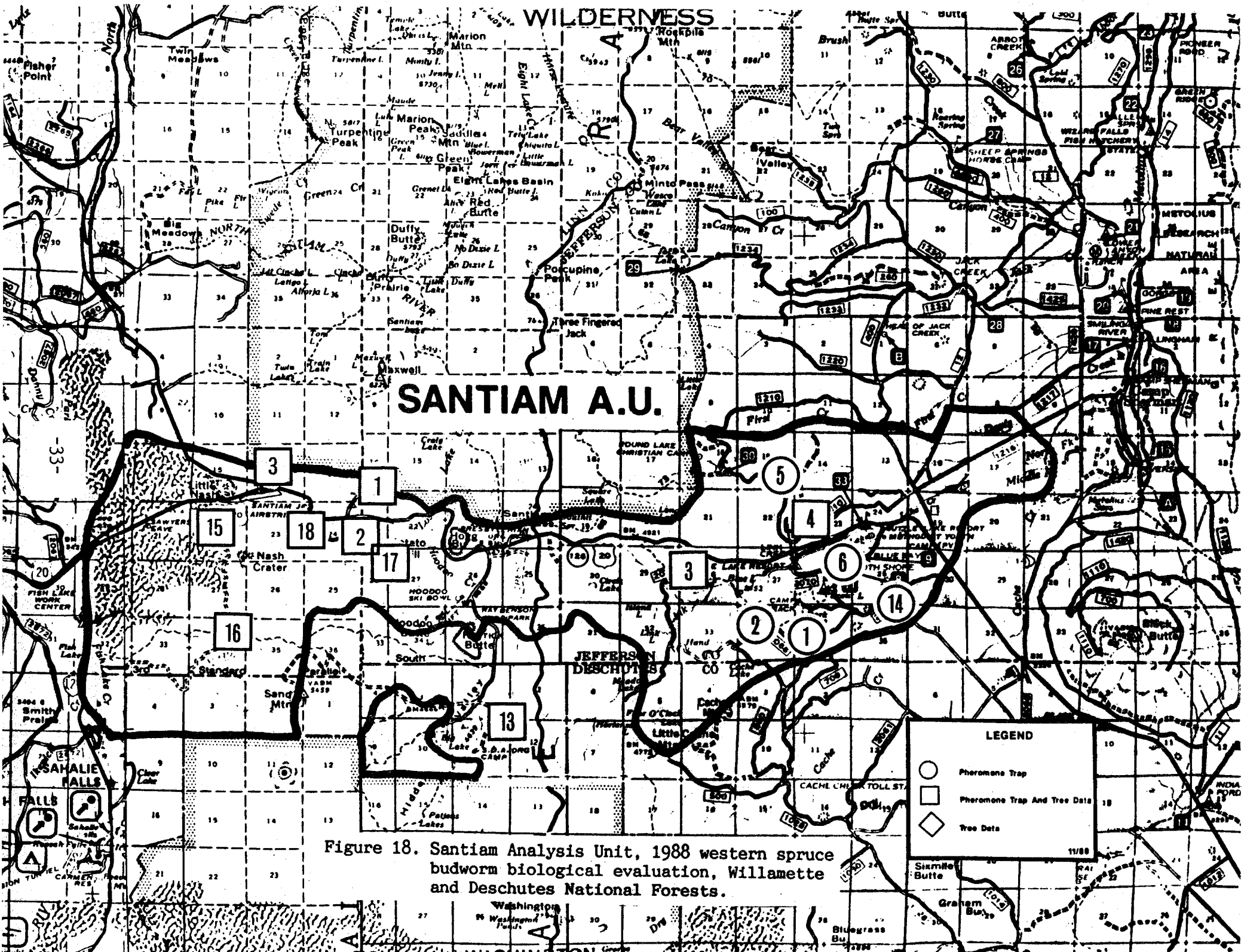


Figure 18. Santiam Analysis Unit, 1988 western spruce budworm biological evaluation, Willamette and Deschutes National Forests.

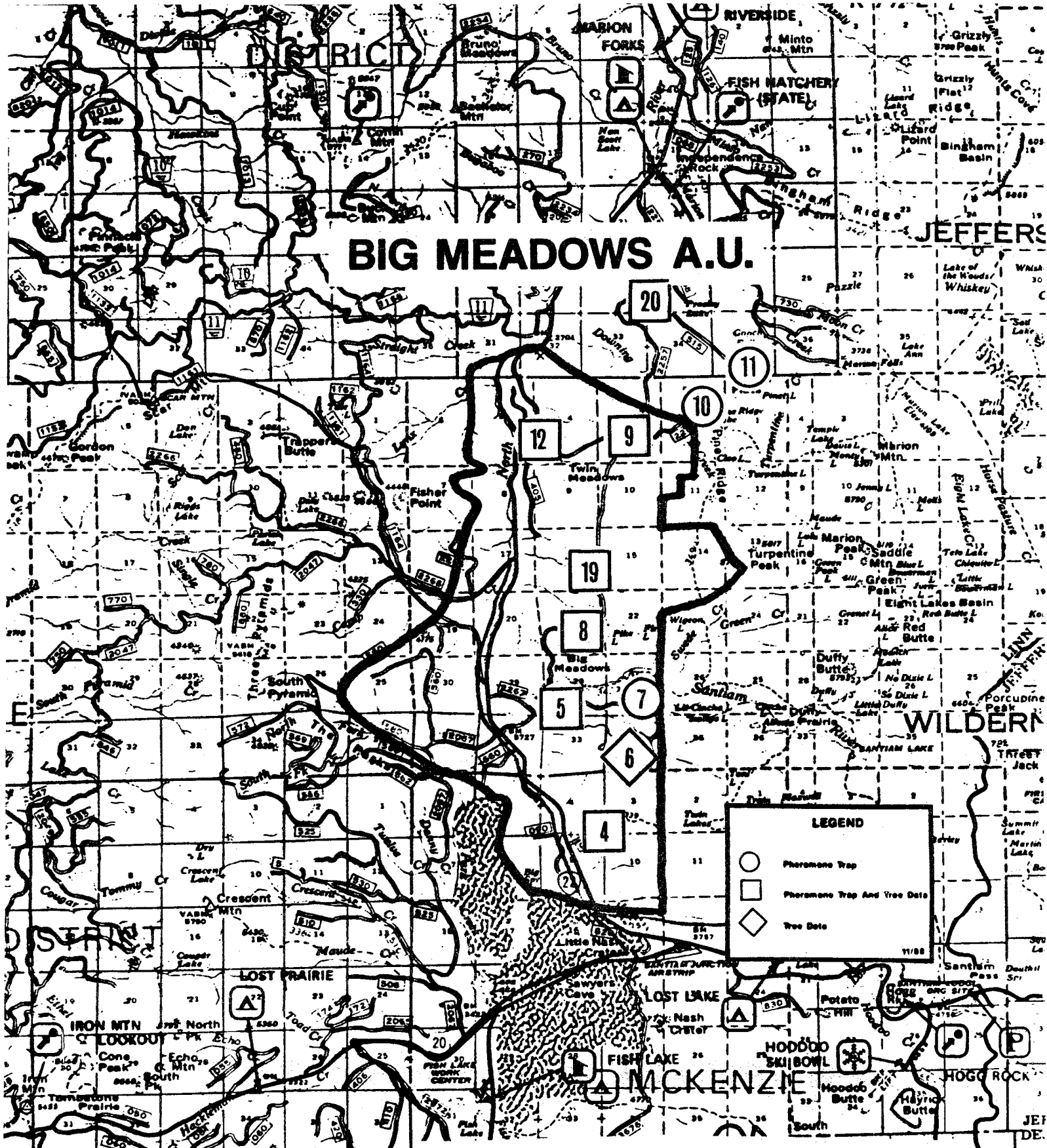


Figure 19. Big Meadows Analysis Unit, 1988 western spruce budworm biological evaluation, Willamette National Forest.

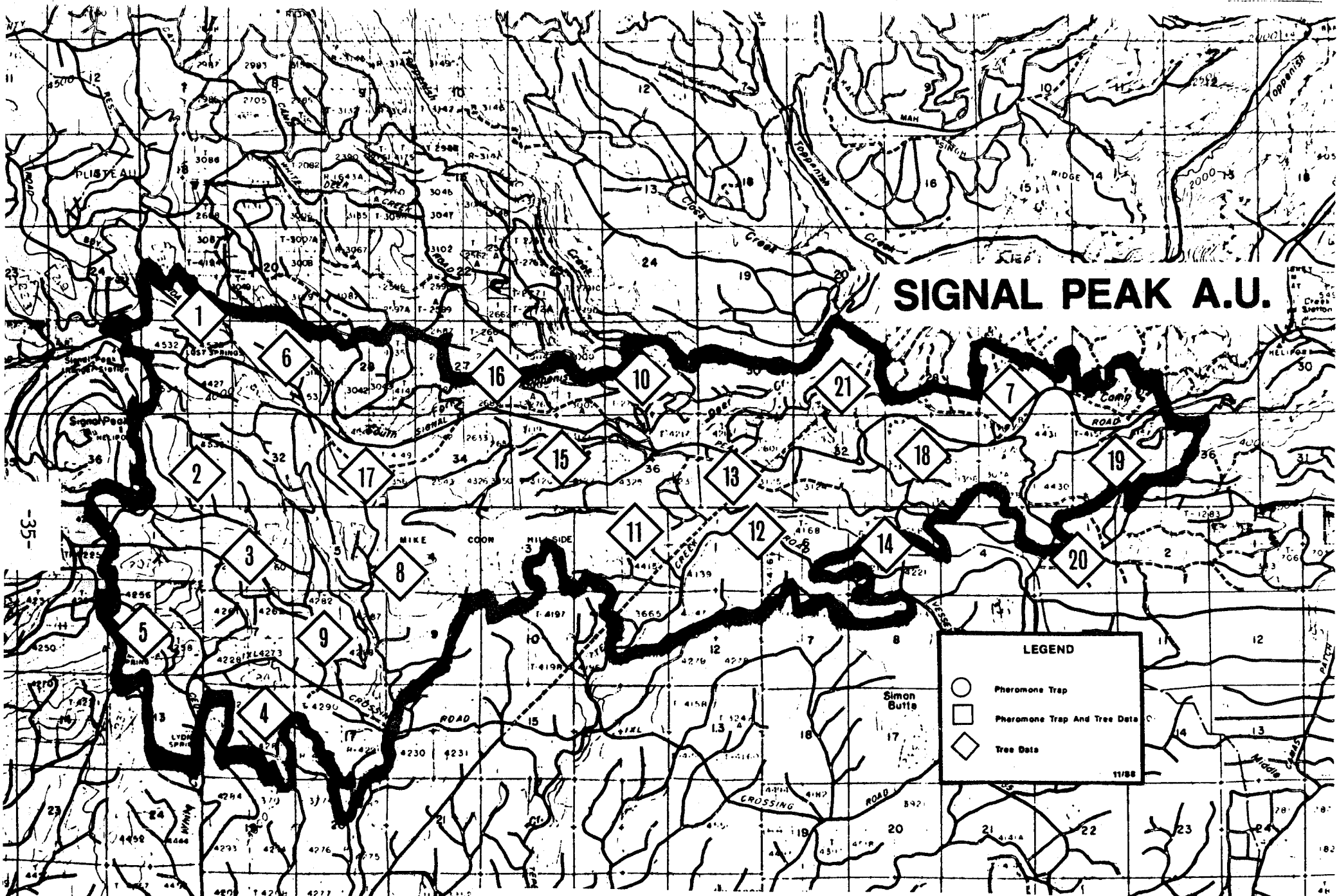


Figure 21. Signal Peak Analysis Unit, 1988 western spruce budworm biological evaluation, Yakima Indian Reservation.

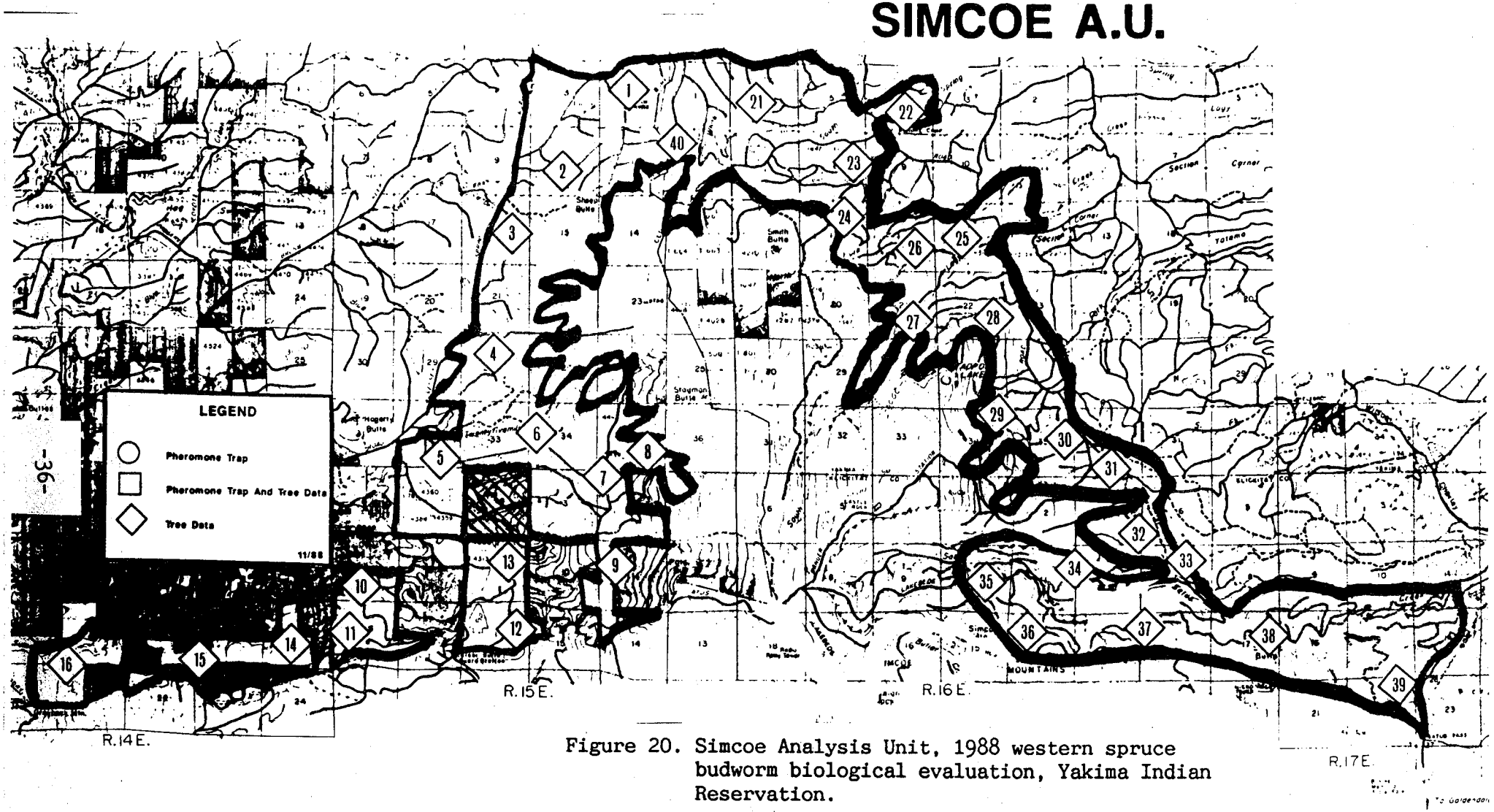


Figure 20. Simcoe Analysis Unit, 1988 western spruce budworm biological evaluation, Yakima Indian Reservation.

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I thank all the people, too numerous to mention, from the 1988 budworm suppression projects who helped deploy the pheromone traps. In particular, I thank Shelly Stelling, Beth Willhite, Dave Wallesz, Tim McConnell, Don Scott, and Craig Schmitt for helping to collect and/or coordinate collection of pheromone traps and tree damage data. I also thank Tom Gregg for help in summarizing and analyzing the data.